UNIVERSITI PUTRA MALAYSIA

CHARACTERIZATION AND AMELIORATION OF SELECTED ACID SULFATE SOILS IN MALAYSIA

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CHARACTERIZATION AND AMELIORATION OF SELECTED ACID SULFATE SOILS IN MALAYSIA

By

MUHRIZAL SARWANI

Thesis Submitted in the Fulfilment of the Requirement for the Doctor of Philosophy in the Faculty of Agriculture Universiti Putra Malaysia

July 2001

DEDICATION

To

My late parents,

Mahrita

And to

Our three wonderful sons: Siraj, Fajri and Zaki

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

CHARACTERIZATION AND AMELIORATION OF SELECTED ACID SULFATE SOILS IN MALAYSIA

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Chairman : Prof. Dr. J. Shamshuddin

Faculty : Agriculture

Researchers in the past had focused their study on the common or standard acid sulfate soils, which are characterized by high iron and the presence of jarosite mottles. Little is known about the characteristics and management of iron-poor acid sulfate soils and this study was conducted to provide the dearth of information. This study aimed to characterize and ameliorate acid sulfate soils in Malaysia. Three common acid sulfate soils in Malaysia namely Teluk, Jawa and Linau series were investigated in three phases. The first phase was concentrated on the characterization of the soils. The second phase dealt with laboratory incubation experiments to study oxidation processes. The third phase was on the ameliorative effects of organic materials, lime, phosphate and silicate application on acid sulfate soils.

Results of the study revealed the presence of both iron-rich and iron-poor acid sulfate soils in Malaysia. The former, represented by the Teluk and Jawa soils, had thick accumulation of iron in the B-horizon. They followed the standard morphological profile commonly found under tropical monsoon climate. The latter, represented by the Linau soil, was low in iron content in the B-horizon. The low

content of iron was most probably due to high organic content enhanced by wet climate in Malaysia. The formation of Fe (III) oxide was hindered when the environment was rich in organics.

Incubation study indicated that oxidation of pyrite resulted in a decrease in pH and the formation of jarosite which, in turn, transformed into short-range order Fe-oxides. The yellow mottles formed during pyrite oxidation were jarosite/natrojarosite and alunite as detected by X-ray diffraction analysis. The oxidation of pyrite was retarded by addition of phosphate and silicate. The retardation of pyrite oxidation was probably due to coating of insoluble materials on the pyrite surface.

Reduction conditions could not be established in the Linau soils upon re-flooding; hence no increase in pH and no decrease in Al occurred. The low active iron (Fe-oxalate) was not necessarily be the source of slow reduction process, but low amount of easily mineralizable organic-C plus low pH were responsible for the slow reduction in this soil. Addition of green manure, rice straw and *Eleocharis dulcis* had the most impact on the reduction process in the Linau soil. Under aerobic conditions, the response of Linau soil to the addition of organic materials was positive. Total and monomeric Al concentration as well as monomeric Al activities in the soil solution decreased, while basic cations activities in the soil solution were increased by the addition of organic materials, especially the mixtures of peat and green manure or rice straw. The mixtures had synergistic effects on the complexation and chelating of Al monomeric. The relationship between relative root length of mung bean and various Al indices was generally exponential. Among the indices, Al monomeric activity and Al^{3+} activity were good predictors of Al toxicity. Growth of cocoa seedlings were significantly increased by the addition of peat mixed with organic materials. Poor growth of cocoa seedlings in the presence of Al^{3+} was manifested by an exponential decrease in the relative total dry weight with increasing activities of Al^{3+}. This study showed that the mixture of peat and green manure provided good conditions for cocoa seedlings growth.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi syarat ijazah Doktor Falsafah

**PENCIRIAN DAN PERBAIKAN TANAH ASID SULFAT
DI MALAYSIA**

Oleh

MUHRIZAL SARWANI

Julai 2001

Pengerusi : **Profesor Dr. Shamshuddin Jusop**

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Para penyelidik di masa lampau menumpukan kajian mereka pada tanah asid sulfat biasa, iaitu tanah asid sulfat yang tinggi ferum serta mengandungi jarosit. Sangat sedikit diketahui mengenai ciri dan pengurusan tanah asid sulfat yang rendah ferum. Kajian ini dibuat untuk mengisi kekosongan maklumat tentang tanah asid sulfat seperti ini. Tiga siri tanah asid sulfat, iaitu siri Teluk, Jawa dan Linau, yang terdapat di Malaysia telah dikaji untuk menentukan sifat dan ciri tanah tersebut dan cara memperbaikinya. Kajian dibuat dalam tiga peringkat. Pada peringkat pertama, kajian dibuat mengenai penciriannya. Pada peringkat kedua, kajian pengeraman dibuat untuk mempelajari proses pengoksidaan pirit. Peringkat ketiga ialah untuk memperbaiki tanah asid sulfat melalui penggunaan bahan organik, kapur , fosfat dan silikat. Kacang hijau dan anak benih koko telah digunakan sebagai tanaman ujian.

Keputusan menunjukkan bahawa kedua-dua tanah asid sulfat tinggi dan rendah ferum dijumpai di Malaysia. Jenis tanah yang pertama, diwakili oleh tanah siri Teluk dan Jawa, mempunyai ferum yang tinggi dalam profilnya, mengikuti profil piawai yang terdapat di kawasan monsun tropika. Sementara itu, jenis yang kedua

diwakili oleh siri Linau, terkurang ferum pada profilnya. Penyebabnya kemungkinan besar ialah pengaruh bahan organik, dibantu pula oleh iklim basah. Dalam suasana seperti ini, pembentukan ferum oksida tergendala.

Kajian pengeraman menunjukkan pengoksidaan pirit telah menurunkan pH dan pembentukan jarosit, yang akhirnya bertukar menjadi ferum oksida. Motel kuning yang terbentuk semasa bahan sulfidik dieramkan adalah jarosit/natrojarosit dan alunit yang dapat dikesan melalui belauan sinar X. Pembentukan motel kuning dan pengoksidaan pirit dapat dicegah melalui rawatan bahan fosfat and silikat. Ini berlaku kerana adanya lapisan selaput tak larut air di permukaan pirit yang dapat mencegah pengoksidaan.

Pembanjiran tanah siri Linau tidak menyebabkan berlakunya keadaan terturun bagi menaikkan pH dan menurunkan kandungan Al. Penyebabnya bukan ferum aktif (Fe-oksalat) yang rendah di dalam tanah siri ini tetapi kerana rendahnya kandungan C organik mudah dimineralisasi serta nilai pH tanah yang rendah. Oleh itu, penambahan bahan organik seperti baja hijau, jerami padi dan *Eleocharis dulcis* dapat meningkatkan proses penurunan tanah siri Linau. Penambahan bahan organik pada tanah siri Linau dalam keadaan aerobik juga memberikan keputusan yang baik. Penambahan bahan organik dapat menurunkan kepekatan Al total dan monomerik serta aktiviti Al monomerik sehingga ianya tidak menjadi toksik lagi. Penambahan bahan organik juga dapat meningkatkan aktiviti bes di dalam larutan tanah. Tanah gambut yang dicampur dengan bahan organik yang berkualiti tinggi seperti baja hijau dan jerami padi ketika digunakan pada tanah asid sulfat memberikan kesan sinergistik. Hubungan diantara panjang akar kacang hijau relatif dan berbagai indeks Al bersifat eksponensil. Aktiviti Al monomerik dan aktiviti Al^{3+} adalah indeks keracunan Al yang baik. Pertumbuhan anak benih koko meningkat secara nyata dengan rawatan campuran gambut dan bahan organik lain. Terbantutnya pertumbuhan anak benih koko dengan kehadiran Al^{3+} ditunjukkan oleh penurunan secara eksponensil berat kering total dengan bertambahnya Al. Kajian ini menunjukkan bahawa campuran gambut dan baja hijau memberi keadaan yang baik bagi pertumbuhan anak benih koko.

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I certify that an Examination Committee met on 18th July 2001 to conduct the final examination of Muhrizal Sarwani in his Doctor of Philosophy thesis entitled "Characterization and Amelioration of Selected Acid Sulfate Soils in Malaysia" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Act 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy

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I hereby declare that this thesis is based on my original work except for quotations and citations which, have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

MUHRIZAL SARWANI

Date: 7th August 2001

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